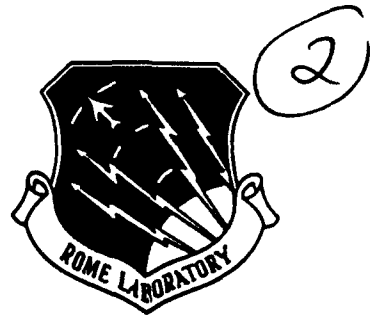

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Final Technical Report
May 1992

CATSS DATABASE DEVELOPMENT (CATSS DB)

PAR Government Systems Corporation

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13. ABSTRACT (Maximum 200 words)

This report documents the technical results of the Cartographic Applications for Tactical and Strategic Systems Database (CATSS DB) effort. The CATSS DB effort was a key milestone in supporting the evaluation and delineation of the Air Force requirements for digital spatial data. This document describes the content, structure, schema, and attribution required to support known Air Force's requirements. The result of this effort is a database which has been implemented within the intelligence cartographic facility at Rome Laboratory. This capability supports the loading and creation of data structures/formats required to support known operational requirements. In addition, it provides the technical base to define and validate new spatial data requirements, establish standards for data contents/structures, and the development of algorithms and applications software for functional demonstration.

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1. INTRODUCTION

1.1 PURPOSE

This document is the Final Technical Report delivered under the CATSS Data Base Development contract. The project scope included a broad survey and assessment of USAF digital cartographic data requirements and development of a laboratory data base system for ingesting, structuring, and analyzing spatial cartographic data. This report summarizes the project objectives, deliverables, and technical accomplishments pertaining to: the requirements survey and data analysis, and development of the laboratory data base system. The Final Technical Report represents an overview of the project although the reader is advised to consult other project documentation (see Section 2.2) regarding specific results of the requirements analysis or description of the developed laboratory system.

1.2 CONTENTS

The organization of the Technical Report is as follows:

- Section 2 presents the project purpose and summarizes the effort's key accomplishments. Also, all deliverable documents are identified.
- Section 3 provides a description of the digital cartographic data requirements analysis and associated data base of requirements information, and describes the characteristics of the resultant DCD product specification.
- Section 4 presents an overview of the laboratory data base system, including the system design, data base structure, system configuration, and user functionality.

1.3 ACRONYMS

The acronyms used in this report are identified below.

AFSC	–	Air Force Systems Command
AOI	–	Area of Interest
ASI	–	Applications Software Interface
C3	–	Command, Control, and Communications
CATSS	–	Cartographic Applications for Tactical and Strategic Systems
CCT	–	Computer Compatible Tape
CONUS	–	Continental United States
COTS	–	Commercial Off-the-Shelf

CTAF	–	Cartographic Traceability and Analysis Function
DBA	–	Data Base Administrator
DCA	–	Digital Cartographic Applications
DCD	–	Digital Cartographic Data
DCE	–	Data Capture and Edit
DCL	–	Digital Command Language
DFAD	–	Digital Feature Analysis Data
DLMS	–	Digital Land Mass System (comprised of DFAD and DTED Products)
DMA	–	Defense Mapping Agency
DMASC	–	DMA Systems Center
DPS	–	Digital Production System
DTED	–	Digital Terrain Elevation Data
FACS	–	Feature Attribute Coding Standard
GFE	–	Government Furnished Equipment
GIS	–	Geographic Information Systems
IFF	–	Interim File Format
IRRP	–	Image Systems Division, Products Branch
MMI	–	Man-machine Interface
NFF	–	Neutral File Format
NRT	–	Near-Real Time
RDBMS	–	Relational Data Base Management System
RL	–	Rome Laboratory
RTNEPH	–	Real Time Nepthanalysis
SLF	–	Standard Linear Format
SOF ATS	–	Special Operations Forces Aircrew Training System
TM	–	Thematic Mapper
TTD	–	Tactical Terrain Data
USGS	–	U.S. Geological Survey
VOD	–	Vertical Obstruction Data
WDB II	–	World Data Bank II

2. PROJECT PURPOSE AND ACCOMPLISHMENTS

2.1 OVERVIEW OF PROJECT OBJECTIVES

The CATSS Program is a major initiative by RL and the USAF with the goal to achieve overall effectiveness in applying digital cartographic data to a wide and growing spectrum of USAF systems. The purpose of this phase of the CATSS Program was to establish a laboratory system that would provide the technical base to define and validate data requirements, establish standards for data content/structures, and develop algorithms and applications software for functional prototyping and demonstrations. This laboratory capability will allow future system developers to capitalize on previous accomplishments and consequently minimize technical risk and cost during system specification and development.

The Data Base System (DBS) is a key component of the CATSS Program and supports the evaluation and technical definition of USAF requirements for digital cartographic data content and structure(s). RL's intent is to establish a laboratory capability to ingest and integrate data structures/formats required for representative system functions and applications. This laboratory capability will entail the creation of data structures that will support weapon system functions and algorithms. The accomplishment of these activities will provide the proof of concepts regarding data content/structures, algorithms, and functional software. Specific challenges of the DBS design and development included techniques and methods to deal with: the various digital source data bases, which are disparate in terms of data coding, format, and spatial structure.

2.2 PROJECT DELIVERABLES

The following documents comprise the complete list of project deliverables, including this Final Technical Report (FTR):

Item	Name
A001	Monthly Status Reports, November 1987 through January 1991.
A002	Software Requirements Specification for the CATSS Laboratory Data Base Development System, 25 July 1988.
A003	Software Top Level Design Document for the CATSS Laboratory Data Base Development System, 30 December 1988.
A004	Interface Requirements Specification for the CATSS Laboratory Data Base Development System, 14 September 1989.

A005 Interface Design Document for the CATSS Laboratory Data Base Development System, 20 January 1989.

A006 Data Base Design Document for the CATSS Laboratory Data Base Development System, May 1989.

A007R Software Product Specification for the Cartographic Applications for Tactical and Strategic Systems (CATSS) Laboratory Data Base System, 26 September 1990.

A008R Software Programmer's Manual for the Cartographic Applications for Tactical and Strategic Systems (CATSS) Laboratory Data Base System, 15 August 1990.

A009R Software User's Manual for the CATSS Laboratory Data Base System, 13 August 1990.

A010R Software Test Plan for the CATSS Data Base Development System, 6 February 1990.

A011 Technical Report (Final), 22 March 1991.

A012+ United States Air Force Digital Cartographic Data Product Specification, Volumes I, II, and III, January 1989.

2.3 PROJECT ACCOMPLISHMENTS

The following discussion provides highlights of key project accomplishments and system development strategies.

USAF Cartographic Data Requirements Analysis: The USAF requirements information was substantially outdated at the time of project initiation and was in need of a major update. PGSC and RL jointly developed a comprehensive plan for surveying of DCD requirements which PGSC, RL, and Defense Mapping Agency (DMA) personnel conducted during the 1988 time frame. Over 100 system environments were identified with current or projected data requirements. Automated tools were developed, including relational data base and query/ report software, to organize, query, and summarize the information collected. The original data base still exists under a VAX Ultrix environment using the Informix relational data base management system (RDBMS). Portions of the requirements data were also loaded into the RL CTAF data base under a separate activity.

Incorporation of Evolving Data Standards: Early in the project the decision was made to standardize data formats and coding schemes where appropriate. The DMA Feature Attribute Coding System (FACS), being developed under the Digital Production System (DPS) Mark 90 (Section 100 Glossary of Features and Attributes), was adopted as the basis for both the requirements survey and the Data Base System development. Thus, the methodology for defining/

recording feature and attribute requirements and laboratory data base research under the DBS are consistent with the DMA coding standards. No single DoD or DMA standard exists for spatial data representation. The past standards, including SLF and DLMS, as well as the evolving prototype Mini-topo data format and topology conventions, were considered in the design. Given the requirement to integrate data derived from the DMA standard products, a Mini-topo 'like' structure was selected because it represented the most complex data structure (i.e., three-dimensional and fully integrated topology) to be processed in the laboratory.

System Configuration Strategy: Development of the CATSS DBS — co-located on the CATSS VAX (VMS) and a Sun 3/60 Workstation — was completed and is operational. Software on the CATSS VAX includes primarily FORTRAN code, several C programs, and DCL command files (including Remote Copy functions) to provide user interface with programs located on the CATSS VAX or on the Sun Workstation. Software on the Sun includes C programs, shellscripts, menus, and the System 9 GIS COTS package which support data input/output and data base graphic display, editing, and analysis.

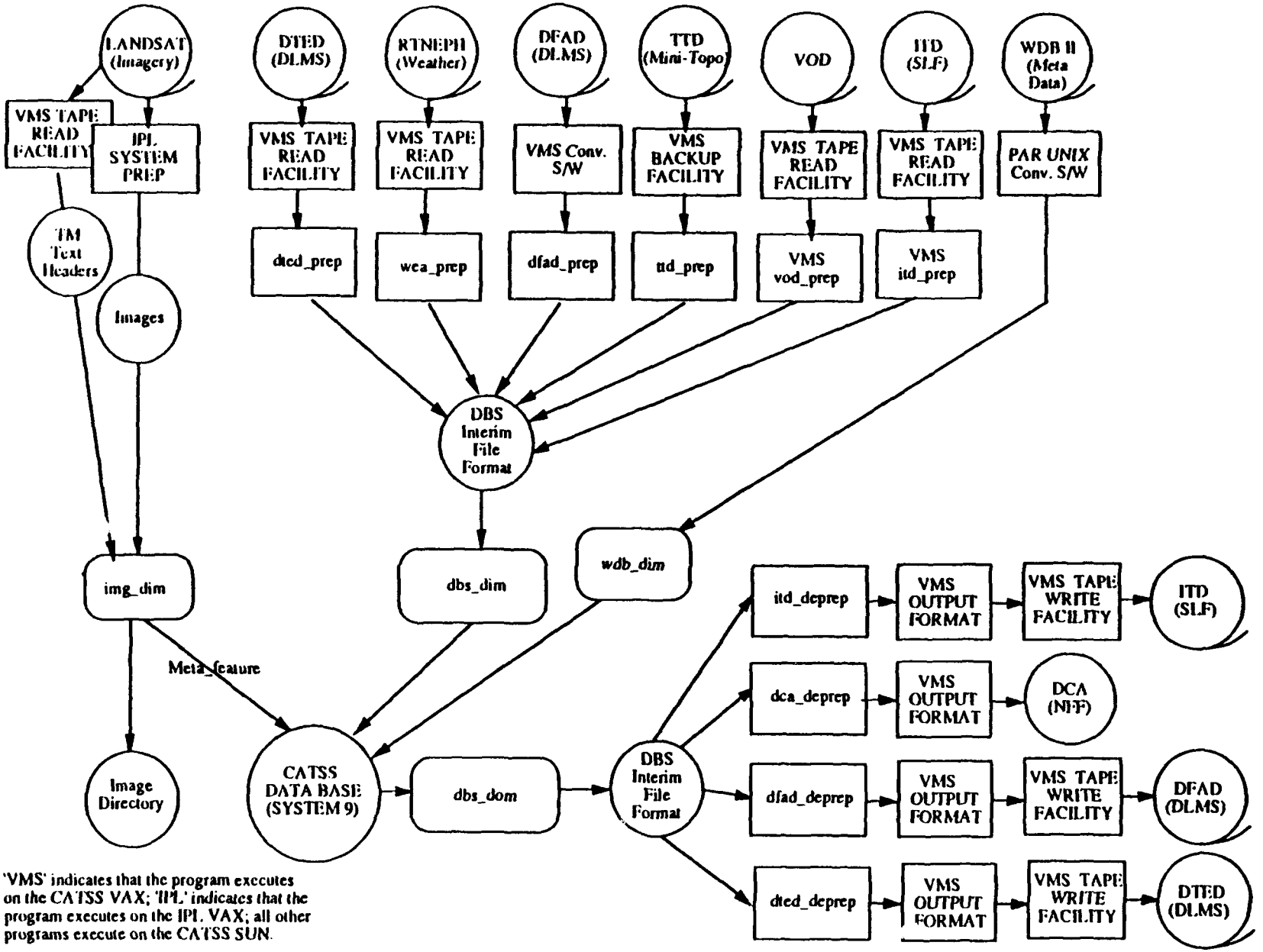
Digital Product Data Import and Export: The CATSS DBS supports loading into the on-line data base and subsequent manipulation/output of the formats noted below. As shown in Figure 2-1, the data formats are converted from their native product formats to a common Interim File Format (IFF) for import/export to/from the GIS package. The IFF is generated by the various 'prep' routines as input to the dbs_dim (data input module) and generated by the dbs_dom (data output module) for input to the various 'deprep' routines. This implementation approach allows for the future addition of other prep/deprep routines to input/output additional product types (e.g., Digital Chart of the World, etc.). It also isolates the entire suite of prep/deprep conversion software residing on the CATSS VAX and on the Sun so that version upgrades to the DBS — or even interface to another GIS — will have minimal impact.

Input Formats:

- Digital Feature Analysis Data (DFAD) in DLMS format, including Edition 1 (without Data Set Identifier (DSI) and Accuracy (ACC) records) and Edition 2 (with DSI and ACC records)

- Digital Terrain Elevation Data (DTED) in DLMS format, including Edition 1 (without Data Set Identifier (DSI) and Accuracy (ACC) records) and Edition 2 (with DSI and ACC records)

- Interim Terrain Data in Standard Linear Format (SLF)



NOTE: 'VMS' indicates that the program executes on the CATSS VAX; 'IPL' indicates that the program executes on the IPL VAX; all other programs execute on the CATSS SUN.

Figure 2-1. CATSS DBS Input/Output Flow

- Tactical Terrain Data (TTD) in Mini-topo (vertically and horizontally integrated) format
- Vertical Obstruction Data (VOD)
- Real Time Nepthanalysis (RTNEPH) weather data
- Landsat Thematic Mapper (TM) Computer Compatible Tape (CCT) format
- World Data Bank II (WDB II) for user review and locational reference at meta-data level

Output Formats:

- ITD in SLF format, including the capability to generate text (i.e., TXT block defined by the SLF specification)
- DFAD in the DLMS format
- Digital Cartographic Applications (DCA) Neutral File Format (NFF), which provides data to the CATSS DCA functions

Integrated Data Base Structure: The CATSS DBS supports the concept of a three-dimensional, seamless data base with the capability to handle horizontally and vertically topological cartographic data. The CATSS DBS currently records the spatial extents and meta-data for each data set directly loaded into the DBS. A basic tiling scheme was implemented which subdivides the earth into regular squares (variable in number although currently set at eight). With this scheme only meta-data represents the tiled areas and actual data is physically removed from the 'active' data base until the user requests the area of interest. A Global Project maintains meta-data and spatially indexes all DBS holdings.

3. DIGITAL CARTOGRAPHIC REQUIREMENTS ANALYSIS

This section presents a review of the methodology used to determine and present Air Force digital cartographic data (DCD) requirements. It summarizes the purpose and structure of the DCD Requirements Data Base. A review of the resultant USAF DCD Product Specification is then presented.

3.1 ANALYSIS METHODOLOGY

3.1.1 Purpose and Scope of Requirements Definition

CATSS DCD requirements definition encompasses Air Force system requirements for navigation; geopositioning; weapon delivery; display; intelligence analysis; mission planning; command, control, and communications (C3); and avionics support. DCD requirements for Air Force training systems and visual and sensor simulators were specifically excluded because HQ AFSC has delegated these requirements to the Training Systems System Program Office, ASD/YW, under the tri-Service sponsored and approved Project 2851.

The DCD specification developed under this contract identifies current and evolving Air Force digital cartographic data requirements addressed during a HQ USAF-sponsored survey of Air Force systems conducted in FY88. The survey included both operational systems and systems or technologies under development whose performance depends on or may be improved through the use of digital cartographic data.

The CATSS Requirements Data Base, and the USAF DCD Product Specification derived from it, result from an in-depth investigation of Air Force-wide DCD requirements. Although the initial information cutoff date for this specification was 19 August 1988, more current survey information has been, and continues to be, received by the CATSS Program Office at RL. Accordingly, the data base and the resultant specification will require follow-on update.

The raw survey technical requirements collected by the CATSS team and reported in the specification have not been formally validated by HQ USAF/INTB. The mission of the RL CATSS is to systematically collect the requirements data and to objectively represent the technical issues in the specification. Resolution of the issues and validation of the requirements are a joint responsibility of HQ USAF/INTB and HQ DMA/PR.

3.1.2 Survey Procedures

The joint RL/PGSC project team determined that the DCD requirements should be baselined and defined within the context of the Defense Mapping Agency's evolving MARK 90 Feature Attribute Coding Standard (FACS). By doing so, modifications (additions, changes, deletions) to the baseline could be easily tracked between the user and the producer, and the results would provide meaningful input to DMA's Digital Production System (DPS) effort. At the time the CATSS Requirements Data Base was established, a snapshot of the MARK 90 RFC E20-011 Data Base (defined by the Section 100 Glossary) was used to establish the "data content" baseline; i.e., features, attributes, and associated definitions according to the Feature Attribute Coding Standard (FACS). As applicable, the various product specifications were referenced by Air Force users to derive feature selection/inclusion conditions. These product specifications are also MARK 90 editions. When a system specified additional features or attributes, they were extracted from DMA's more recent RFC E20-012 and E20-013 glossaries to update the CATSS baseline. CATSS-unique features and attributes were generated only when a suitable definition could not be located in one of the MARK 90 glossaries.

The FY88 CATSS digital cartographic data (DCD) requirements analysis survey was jointly developed and performed by cognizant representatives from RL/IRRP, DMASC, and PAR Government Systems Corporation. It was conducted using a phased approach. The Level I survey was designed to gather a comprehensive, multiple-dimension view of Air Force-wide DCD requirements. The Level II survey, conducted at the user sites, was designed to collect detailed DCD content requirements. Information obtained from the Level I surveys was analyzed to categorize and prioritize systems requirements for DCD and to identify candidates for the Level II survey.

The Level I survey solicited the following types of information from USAF programs and systems:

- System Mission Areas
- Primary and Subordinate Functions Requiring DCD
- System Acquisition/Development Status
- Supported Weapon Systems/Technology Areas
- Sensors Employed and Accuracies
- System Level Accuracy Requirements
- Current or Planned Usage of DMA MC&G Products
- DCD Accuracy and Resolution Requirements

- Data Structures, Formats, Transfer Media, and Update Requirements
- Cartographic Data Categories Required (i.e., Feature Data, Vertical Obstructions, Terrain Elevation Data, Navigational Aids/Aeronautical Data, Geopositional Data, Reference Scenes, Gravity, Magnetic Data, and Other Data)

A total of 242 Air Force system users were formally solicited by mail via the Level I survey form; nearly one-half (114) of all solicited systems returned a completed Level I survey. It was presumed that those systems not responding to the survey either had no current or future DCD requirements or could not specify requirements at that point in time. Of the 114 responses, fourteen (14) could not be used because they were not substantive in content. Each of the remaining 100 systems surveyed, as well as additional systems identified as a result of Level I survey responses (for a total of 109 systems), was evaluated for significance of need for digital cartographic data. A DCD rating of 1 to 7 was assigned to each system as follows:

Evaluation Criteria	DCD Rating	Number of Systems
Driver – system has significant near-term requirement	1	24
Potential Driver – system has significant future DCD requirement	2	16
Moderate – system has requirement for DCD improvements	3	16
Low – system has low-level usage of DCD and is generally satisfied	4	12
Tracking – New Program, R&D stage of development and far-term/undefined DCD requirement	5	18
Possible Tracking – Insufficient survey data or satisfied (no new DCD requirements)	6	15
Beyond Scope – Non-USAF, Program Cancelled, or Simulator/Training System	7	8

Other factors that influenced assignment of the DCD Rating included: current or planned usage of DCD, whether or not existing DMA products would satisfy system requirements, stage of system development/operational status, system user's knowledge of DCD requirements, and funding support for system development/maintenance.

After reviewing and analyzing the initial survey responses, a second and more detailed survey form was developed to collect specific cartographic feature data requirements for Air Force systems designated as having significant requirements. Forty-four (44) systems that have substantive and/or representative requirements were identified as "drivers" or "potential drivers" through analysis of the Level I survey results; then the point-of-contact for each of these systems was contacted for a follow-up site visit. In some cases, multiple site visits were required. CATSS team members interviewed system representatives on site to clarify Level I survey responses and to compile information for the Level II survey form. The Level II site surveys were performed during the May through August 1988 time frame.

The Level II survey involved jointly filling out a cartographic feature-attribute-function worksheet for each required cartographic feature. A glossary of feature descriptors/attributes was used to aid this activity. Relevant documents pertaining to DCD requirements and cartographic functions within the context of the USAF systems surveyed were also collected during the Level II site visits. Not all system requirements could be represented at the same level of information. Twenty-six (26) of forty-four (44) system descriptions provided the detailed feature/attribute information required to generate the Feature/Attributes Requirements Table (reference Volume II, Section 300, Table 300-1 of the USAF DCD Product Specification).

3.2 REQUIREMENTS DATA BASE

3.2.1 Purpose

The purpose of the CATSS Requirements Data Base was to organize and maintain the information contained in each survey form with minimal interpretation. The intent was to capture the data in as close to "raw" form as possible and to keep the activity of reducing/summarizing data and the drawing of conclusions completely separate from the data basing activity. The CATSS Requirements Data Base contains survey data for 109 systems and includes (as a minimum) a system description for each system or technology area defined. Detailed feature-attribute-function information was collected and stored in the data base for twenty-six (26) of the forty-four (44) systems surveyed on site. Software was developed to generate detailed reports, interim data reduction reports, and high-level summary reports. The majority of reports included in the USAF DCD Product Specification were generated directly from the data base, using report generator software.

3.2.2 Data Base Structure

The CATSS Requirements Data Base was developed on a VAX system operating under Ultrix using the Informix relational data base management system. Informix tools were used to develop forms/menus to support the process of data entry and data entry verification. Informix 4GL report generator programs and report programs were written to provide reports and (additionally) to verify data base content. Figure 3-1 depicts the CATSS Requirements Data Base structure. As shown, the **cat_system** table is the parent (root) table. Each entry contains the system acronym, name, description, development phase, date information was received, and the DCD priority rating of 1 to 7. Fifteen (15) tables are directly linked to it via the unique numeric **sys_id** key:

- **cat_sys_poc** – Each entry defines a USAF system point-of-contact (POC). Multiple cat_sys_poc entries may be linked to a cat_system entry.
- **cat_sys_product** – Each entry contains information about a specific product with reference to its use by the system: current vs. planned use, used to generate digital data, used to audit other products, product satisfaction, if not satisfied – deficiency flags include: feature content, attribute content, area of coverage, accuracy, density/resolution, structure/format, portability, media, storage/compression techniques, quality, currency, and compatibility with other products.
- **cat_related_sys** – Each entry allows definition of a system's relationship with another system. It can be used, for example, to link multiple subsystems to a system.
- **cat_sys_mission** – Each entry defines a single mission supported by the system.
- **cat_sys_sensor** – Each entry defines a single sensor type employed by the system.
- **cat_sys_weapon** – Each entry defines a single weapon type employed by the system.
- **cat_sys_acc** – Each entry defines the stated system accuracy, units of measure, error probability, and accuracy text. Usually, only one entry is associated with a specific system.
- **cat_sys_datum** – Each entry defines a single datum the system uses. Forty-two horizontal datums and nineteen vertical datums are defined. Therefore, if all datums were used (unlikely), a system could possible have sixty-one (62) entries associated with it.
- **cat_sys_area** – Each entry defines a codified geographic area of the world where DCD is required. Flag fields indicate whether the area is test and/or operational. Fiscal year and quarter required (e.g., 90-3) and free text are also provided.
- **cat_dcd_acc** – Each entry allows entry of absolute and relative horizontal and vertical accuracies with a common unit of measure (e.g., m - meters) and free text for absolute, relative, and overall accuracy.

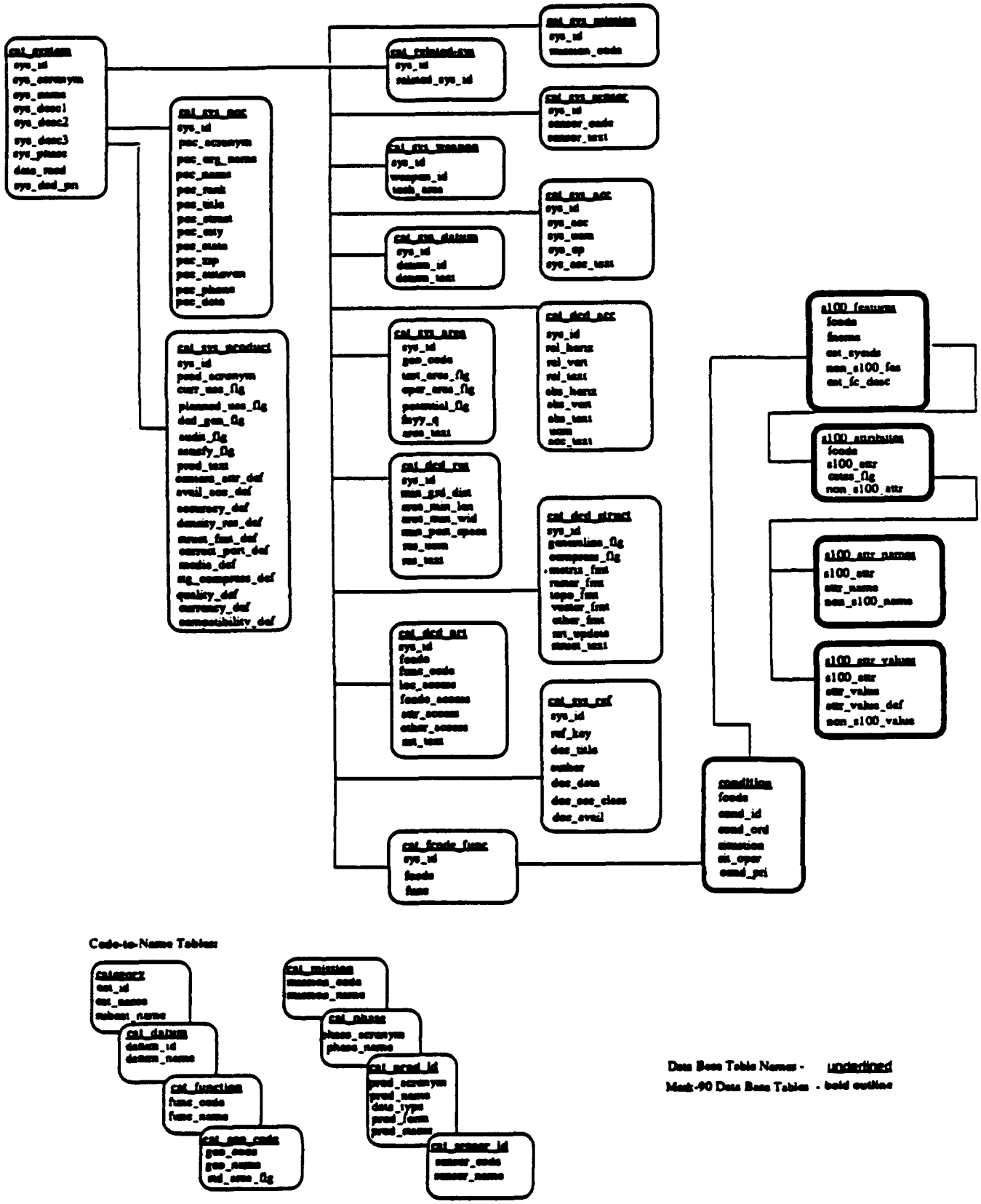


Figure 3-1. CATSS Requirements Data Base Structure

- **cat_dcd_res** – Each entry allows inclusion of minimum ground distance and area minimum length and width for feature capture, minimum post spacing if matrix data, the common unit of measure, and free text.

- **cat_dcd_struct** – Each entry contains information concerning a DCD file structure maintained by the system in question. Flags indicate whether the data is generalized and/or compressed; whether the format is matrix, raster, topological vector, spaghetti vector, or other; and whether near-real-time update is required. A text field is also provided.

- **cat_dcd_nrt** – Each entry indicates the feature (fcode), function, access mode (location, fcode, attribute, and/or other method), and text concerning near-real-time (NRT) update requirements.

- **cat_fcode_func** – Each entry identifies a feature (fcode) and associated function. It is a table in its own right, but also provides the link to five MARK 90 DPS Data Base tables, which in turn provide definition of each feature, its attributes and attribute values, and the conditions under which the feature will be selected.

- **cat_sys_ref** – Each entry identifies a reference document that supports requirements of the associated system. Information includes title, author, date, security classification, and availability.

The five tables outlined in bold on the right side of Figure 3-1 represent the MARK 90 Section 100 Glossary plus amendments/additions as result of the CATSS requirements survey. These tables define each feature, its associated attributes and attribute values, and zero-to-many conditions for inclusion in the USAF DCD Product Specification.

The eight tables at the bottom of Figure 3-1, labeled: **category**, **cat_datum**, **cat_function**, **cat_geo_code**, **cat_mission**, **cat_phase**, **cat_prod_id**, and **cat_sensor_id** provide code-to-name conversions for report generation purposes.

3.3 DCD PRODUCT SPECIFICATION

3.3.1 Product Specification Content

The USAF DCD Product Specification reflects the requirements gathered by the CATSS survey team. These requirements were collected at various levels of detail. For a majority of the systems surveyed, it provides system/technology characterization in terms of: mission areas, cartographic functions supported, usage of DMA products, and weapon systems and sensor systems employed. These reports may be found in Volume I, Appendix A (if classified) or in Volume III (if unclassified). Detailed feature/attribute requirements were processed and reported in Table 300-1 for the systems that were able to provide such detail. Table 300-1 and supporting dictionaries are contained in Volume II of the USAF DCD Product Specification. Appendices B

and C contain special DCD requirements reports: "DCD Requirements for the Special Operations Forces Aircrew Training System (SOF ATS)" and "DCD Requirements for Geodetic and Geophysical Data," respectively. We felt that the SOF ATS requirements uncovered by the CATSS survey should be documented even though they specifically fall under Project 2851 and could not be included with the requirements of non-training, non-simulator systems. Geodetic and geophysical data was reported separately because the information collected was different in nature and could not be tabulated or summarized properly using the summary and reporting tools developed to report cartographic feature data requirements.

3.3.2 Summary of Findings

The following paragraphs provide a brief highlight of trends and areas of concern that surfaced as result of the CATSS survey effort.

Increasing Need for Digital Data

The Air Force requirement for detailed digital cartographic data is expanding at a tremendous pace. This is due to the increasing number of systems under development or operationally fielded and to the increasing and diverse uses of DCD to support system mission areas. The growth rate of digital prototype products continues to soar as system developers define new requirements or amend existing product requirements to address mission support. Diversification, rather than commonization of requirements to serve multiple using systems, has all too clearly been the modus operandi. Many systems currently perform extensive data transformations and reformatting (including use of hardcopy products to generate digital products) in order to conform to their unique data models – possibly causing inadvertent data degradation, as well as delays in operational readiness. These problems were noted for many of the USAF systems surveyed. Reconnaissance/strike systems and systems with a requirement to perform real-world mission rehearsals would be most severely impacted by data degradation and processing delays.

Interoperability a Must

Interoperability of the digital data among systems, as well as among the Services, is needed. This will relieve the impact on DMA of producing many differing products and also simplify the update cycle. In order to be effective, inter- and intra-Service systems, such as the Joint Surveillance and Target Attack Radar System (Joint STARS) and the Mission Support System (MSS), must work from a common view of the world. Data source, content, format, and update cycle need to be compatible, if not the same. The proliferation of system-specific digital cartographic data bases resulting from digitization of hardcopy products by individual Air Force

system developers is counterproductive in many ways. It expends large amounts of system personnel time and monetary resources that could be used in better ways; it directly counters the requirement for inter-Service operability; and it continues to extend the need for and ineffective use of hardcopy products when digital products are required.

Feature Data Structure

The definition and implementation of a logical structure for digital cartographic data is required in order to support interoperability and to eliminate redundancy. As revealed by many of the surveys, the logical structure supporting feature topology is required. That is, for each feature, spatial relationships of features that are touching/adjacent on the same theme or overlay, or above or below on different themes or overlays must be maintained. The completed surveys also revealed the need for data currency and the requirement for near-real-time (NRT) updates of individual features, as well as the need for periodic feature updates in the form of "changes" from the producing agency. When the logical structure for feature data is defined, it should be able to support the requirements for both update modes.

Terrain Elevation Data Structure

Systems surveyed expressed certain structure preferences for digital terrain elevation data in matrix format (e.g., DTED Levels 1 and 2). Standard interval post spacing is preferred to the current variable post spacing dependent on latitude. Those systems using DTED for display with imagery requested that the origin be changed from the southwest corner to the northwest corner to avoid the need for origin adjustment. Systems using DTED in concert with cartographic feature data do not want the origin changed, however.

Exchange Format Considerations

Since detailed investigations to define a standard exchange format are currently being performed by the U.S. Geological Survey (USGS), specific format recommendations are inappropriate. The following is a list, however, of desired specifications which we believe any exchange format should include. In many cases, the recommendation applies equally to specifications for a logical structure that can be derived from the data encoded in the exchange format:

- Format allows for recording of feature topology (the spatial relationship of features with other related features on the same or different planes).
- Format includes entities and relationships that will allow data access by location (coordinates), by segment (or face), by feature ID (unique key), by feature code

(i.e., FACS code), by feature representation type (area, line, or point), by feature descriptors (attributes), or by some combination of one or more of these items.

- Format supports modification (addition, update, deletion) of individual features or feature groups using the access methods listed above.
- Format allows for a variable number of descriptors (attributes) per feature.
- Format provides a method to define real-world representations of features comprised of component features (e.g., river/stream defined by river/stream left bank and river/stream right bank component features, or defined by river/stream centerline component feature) without being redundant.
- Format allows for locational data (points) to be optionally recorded in two dimensions (x,y) or three dimensions (x,y,z).
- Format supports recording of different coordinate systems (Cartesian or geographic).
- Data encoding and field sizes are transportable and conform to an agreed-upon standard.
- A variety of units of measure (e.g., feet, meters, centimeters, nautical miles, etc.) and units of precision (e.g., n.n, n.nn, n.nnn, etc.) is supported.
- Format allows for the recording of data quality, including: data sources, positional accuracy, accuracy of attribution, logical consistency, and completeness of the data. Information may need to be recorded for the entire map sheet area or for sub-areas or "tiles."

Accuracy, Resolution, Consistency, Feature/Attribute Detail, and Coverage

Both tactical and strategic requirements for digital cartographic data are more stringent than ever before. The completed surveys indicate a need for enhanced accuracy, resolution, detail, and consistency among data types and products. Attribution requirements for both cultural and natural features are quite extensive (as defined in Volume II, Section 300 of the USAF DCD Product Specification). As stated in many of the completed surveys, digital data required to support Air Force systems should not be constrained by hardcopy production requirements. Although background display is an important function, it is only one of many important uses of DCD in the synthesizing of multi-source data into intelligence. Two new requirements for detailed digital cartographic data surfaced during the CATSS survey. First, accurate and detailed digital cartographic data is required for a radius of up to 60 nautical miles for all operational and contingency air bases worldwide, including CONUS. Second, detailed railroad data is needed within CONUS in support of strategic systems. Heretofore, requirements for only training areas within CONUS have been documented. It can be expected that such requirements will increase as defensive systems and mobile offensive systems become operational and expand in scope and number.

Early DCD Requirements Definition

The CATSS survey highlighted the fact that detailed cartographic requirements must be defined early in the life cycle of the program. Previously, the tendency has been to proceed well into the development cycle and then to formally surface the need for digital cartographic data. Thus, in many cases, by the time DMA is given the requirement, the need is critical and the time given to respond is insufficient. Many of the problems summarized above have been recognized and addressed through use of Air Force Form AFR 96-9, "Request for MC&G Support," in accordance with Regulation AFR 96-9. The Digital Production System now under development by DMA will help to solve many of these issues. DMA can only address the requirements they know about, however. The task of surfacing and organizing/unifying requirements for presentation to DMA is required of each Service. Within the Air Force, RL/IRRP has been assigned technical responsibility for this task and will continue to monitor Air Force requirements for digital cartographic data. For example, the eighteen systems given a DCD rating of "tracking" and the fifteen systems given a rating of "possible tracking" should be contacted periodically to ensure that additional requirements (as they surface) are folded into the portfolio of unified USAF digital cartographic data requirements.

4. CATSS LABORATORY DATA BASE SYSTEM

This section presents the functional, hardware, and software characteristics of the DBS laboratory system. Specifically, Section 4.1 examines the purpose of the laboratory system and factors driving the functional requirements of the DBS. Section 4.2 describes the hardware platform of the DBS. Section 4.3 summarizes the DBS data base design and structure. Finally, Section 4.4 provides a concise description of DBS system functionality and operational characteristics.

4.1 PURPOSE OF LABORATORY SYSTEM

The goal of the CATSS DBS was to provide a laboratory system for the integration and manipulation of digital cartographic data products which would support the evaluation and technical definition of USAF requirements for digital cartographic data content and structure(s). The approach to this goal was to establish a laboratory capability to load and create data structures/formats required to support the emulation and demonstration of representative weapon system functions, applications, and algorithms.

The required capabilities of the DBS can be summarized as follows:

- Interface to Digital Cartographic Data Applications: this interface will provide the requisite data to the laboratory digital data applications including the Digital Cartographic Applications Segment and the Sensitivity Modeling Segment. These applications will require a variety of digital data for testing and demonstrations. Two levels of data access will be required:

  File Level: consisting of selected data content/structure which has been specially prepared based on parameters such as AOI, feature content, or format.

  Feature Level: consisting of specifically requested feature information for interactive or near-real-time applications based on transaction query parameters such as data set, feature type, location, etc.

- Interactive Query of Geographic Information: the DBS is intended to provide basic facts, as well as derived geographic feature and terrain information. The derived information is intended to include inferences which can be gleaned through relational, spatial, or boolean processing. This capability will be serviced by a combination of standard and ad hoc forms of query processing.

Other capability requirements and technical factors considered in the functional scoping of the DBS include:

- Digital Cartographic Data Requirements:

  Data Types – a growing need exists to store/access multiple types of data, including cartographic, terrain, imagery, intelligence, weather, etc.

  Cartographic Feature Content – applications require various kinds content such as depth/level of feature categories/types, feature detail, and attribution.

  Formats and Reference Systems – standard vs. special data formats, internal vs. user's requirements for geographic reference frames.

  Structure – display data, topology, network, matrix.

  Coverage – geographic extent, 'seamless' data sets.

  Quality – general data verification, data degradation required to support sensitivity modeling.

- Evolution of the Digital Data Production Program: The primary supplier of digital cartographic data is the Defense Mapping Agency. The standard digital data available today is represented principally by the DLMS program, although the DMA is in the middle of a major modernization program which will result in substantial changes. The DBS will thus need to take advantage of current/near-term digital data and, at the same time, accommodate strategies for using the more comprehensive future data base. Considerations should include the benefits of a special USAF extract from the master DMA digital feature data base, as well as the potential utility of alternate formats/media such as represented by the evolving Map/Chart CD-ROM program.

- Data Base Updates and Currency: The need exists to provide direct updates to DBS on-line data that emulate field updates of selected features due to military operations, such as the destruction of transportation features which would substantially impact applications such as predictions of vehicle routing.

- Potential Application of CATSS GIS/RDBMS Technology: A key issue was the emphasis placed on the DBS as an interactive/ad hoc query information system. Presently, our perception is that the USAF laboratory should be striving for new data base concepts and technology which can be used in multiple roles: 1) as a geographic information system that demonstrates the utility of interactive spatial queries; and 2) as a supplier of specialized data formats to applications software and external systems.

4.2 SYSTEM CONFIGURATION

The CATSS Data Base System is configured on a Sun 3/60 workstation and VAX 8350, connected via ethernet. The VAX 8350 consists of 32 megabytes of memory, the VAX/VMS 4.6 operating system, and FORTRAN (version 4.7) and c (version 2.3) compilers. The GFE Sun 3/60 consists of 8 megabytes of memory, the UNIX (BSD 4.2) operating system, c compiler, and the Prime/WILD System 9 Geographic Information System (version 2.1.1) and embedded Rodnius EMPRESS Relational Data Base Management System. The Sun 3/60 was upgraded to include 12 megabytes of memory and a 1.4-gigabyte removable disk drive, and was configured with a minimum of 100 megabytes of swap space for System 9 operation. Details of the equipment configuration can be found in the CATSS DBS Software Requirements Specification.

4.3 DATA BASE DESIGN AND STRUCTURE

The CATSS DBS design was required to maintain a master (worldwide, integrated) holdings data base as well as separate Temporary Holdings. Sources for DBS holdings varied in complexity, format, content, and data representation (e.g., TTD/Mini-Topo, DLMS/DFAD, vector cartographic, textual or raster). The DBS also required a rather extensive set of functionality which would allow this data to be manipulated in various ways. The System 9 GIS, designed with the intent to handle large, seamless databases, was selected as the core for development because it was the only commercially available GIS (at that time) that could accommodate an integrated, 3D, topological data structure (such as TTD/Mini-Topo).

However, although it exhibits obvious good qualities, System 9 does use some internal structuring and data organization techniques that constrain the storage and manipulation of very large databases, such as the CATSS DBS. System 9 specifically requires that all related data be collectively contained within a single master data base, referred to as a *project* data base. In System 9 parlance, a *partition* is a working copy of a subset of a project; the subset is defined by both AOI and feature/data content. The ATB_viewer, a System 9-related prototype product, which provides a basic toolbox of utilities (commands) to access and display partition data, and underlying software libraries, such as the object and menu handlers, provides for customized development of functionality not readily available under the standard System 9 implementation.

Initial evaluation of the practicality of implementing the global CATSS data base within a single System 9 project data base surfaced the following challenges:

- It was estimated that even a nominally populated global data base would not entirely fit on the available on-line disks.

- Mechanisms would need to be devised to keep track of data base information that is not exclusively cartographic in nature (weather, intelligence reports, etc.).
- Mechanisms would need to be devised to provide users with access to the availability of data (overview of data base holdings) without recourse to the data itself.
- It would be difficult to maintain data integrity (corrupt input data would contaminate the entire data base, as would problems occurring during the integration of data from a variety of sources).
- Archives would span off-line volumes.

An alternative design solution involved implementing the global CATSS data base within multiple System 9 project databases over noncontiguous data areas (such as designated test areas). This alternative was also discarded due to the following constraints:

- Multiple definitions of the large data base schema would be difficult to update/maintain.
- Future overlap of areas of interest between projects becomes awkward.
- Overview of separate projects becomes a logistical nightmare.
- Addition/integration of data becomes project-specific.
- References to noncartographic data must be maintained in each project.

An evaluation of the above design considerations made it apparent that the DBS data base needed to be tiled (split up) into manageable pieces. This design required the management of two layers of information or data. The first layer is represented by the meta-feature data describing all holdings within the DBS. The second data layer is represented by the contents of individual tiles of data (not directly accessed by the user) and Temporary Holding partitions (data which the user may display and manipulate). This design was implemented using a System 9 project data base as a "phantom" global data base; this global data base provides a single master schema definition, but never contains any data. Characteristics of this design are highlighted below:

- The project data base serves as the master schema definition and contains no data (is a "phantom" project).
- A special partition exists that describes the actual data base holdings.
- The master data base (actual data) exists as tile partitions of the "phantom" project.
- Temporary copies of the "phantom" are created and used to manipulate data in tiles and user partitions.

The benefits realized from this "phantom" project design are:

- No data exists in the project itself, minimizing use of on-line resources.
- Master data exists only in Tiles.

- The schema definition and System 9-specific information reside in a single data base (feature and attribute definitions, graphic transforms, theme definitions, etc.).
- Master data base (tiles) need not be on line, except for EXTRACT and ADD functionality.
- Master data base can be archived in single tiles and user partitions and brought in as needed.
- "Phantom" project simplifies manipulation of user environment variables.
- "Phantom" project unifies/generalizes overview of all data base holdings.
- "Phantom" project permits arbitrary definitions of AOIs.
- "Phantom" project allows combination/sectioning of AOIs without master data.
- Master "phantom" project (and data base) is not corrupted by addition of new data to copy.

This design concept is diagrammed in Figure 4-1, "CATSS DBS Software-Data Base Hierarchy." This figures shows that the Global Project, Temporary Copy of the Global Project, and Tile Partitions are accessed and maintained through the DBS ATB_viewer and customized software, but the contents of these projects/partitions are never directly viewed by the user. The Database Holdings Partition, however, is accessed and maintained, and its contents are displayed for the user through the DBS ATB_viewer. Temporary Holdings Partitions are accessed and maintained through both the DBS ATB_viewer and System 9; however, the contents of these holdings are displayed (and edited) only through the System 9 Data Capture and Edit utility (DCE) which is activated by the DBS ATB_viewer. Each of these major components of the CATSS DBS data base design is described in further detail below:

Global Project: The CATSS DBS implementation uses one System 9 project data base (the Global Project) to serve exclusively as the schema definition for all CATSS DBS data, the source of the Database Holdings Partition, and controller for data integrity in master/ temporary holdings. This project data base has worldwide extent and contains all System-9-specific CATSS theme (filter) definitions, data representation characteristics (geographic latitude/longitude in thousandths of arc seconds), and symbology for display purposes. It contains no actual data, but simply serves as a template for the manipulation of actual data defined in the Database Holdings Partition and contained in the Tile Partitions and Temporary Holdings Partitions, described below.

Database Holdings Partition: The Database Holdings Partition is a special partition of the Global Project which is used by the CATSS DBS to identify all holdings (master and temporary, vector and nonvector) of the DBS. This partition data base contains all meta-data describing all data holdings of the CATSS DBS; it does not contain any other actual source, tile, or temporary holding data. The contents of this worldwide extent partition

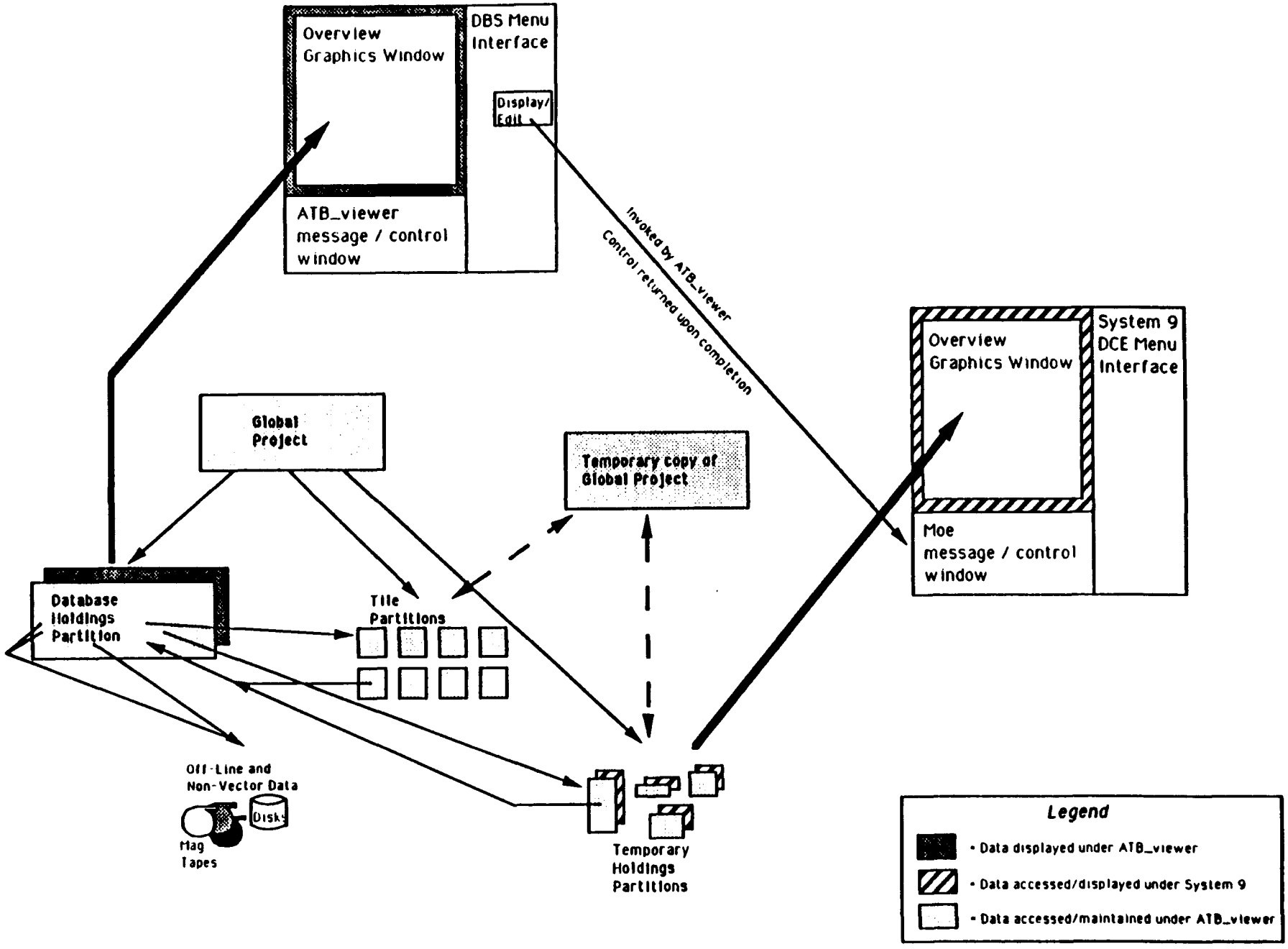


Figure 4-1. CATSS DBS Software-Data Base Hierarchy

are directly displayed to the user in the Overview Graphics Window under the CATSS DBS ATB_viewer interface. To provide a visual point of reference for the user, this partition also contains WDB II data which was directly loaded into it for use as a background on displays.

The following meta-data is contained within the Database Holdings Partition:

- Tile boundary meta-features are used to refer to the actual tiles of data contained within DBS master holdings (Tile Partitions).
- Temporary holding meta-features are used to refer to the actual data contained within Temporary Holdings Partitions.
- Source data meta-features generally refer to data that came from an external format and is now stored (wholly or partially) in either Temporary Holdings Partitions or Tile Partitions. Source data meta-features may also refer to data that is off-line or nonvector in nature (disallowing it from being represented in Tile/Temporary Holdings Partitions). Various source data meta-feature types exist within the DBS, including TTD, DTED, DFAD, etc. Actual feature data contained within Tile/Temporary Holdings Partitions are also attributed under the DBS to identify the source data meta-feature they were derived from, providing a feature history trail.

Temporary Copy of the Global Project: A temporary copy of the Global Project is created and used as a standard System 9 project data base, specifically providing a copy of the CATSS DBS schema definition. Actions performed against data holdings require that a Temporary Copy of the Global Project be made so that Tile Partition data and Temporary Holding Partition data may be manipulated within it to obtain the required result.

Tile Partitions: Tile Partitions are used to contain all vector-type master holdings data within the CATSS DBS. There are four basic types of master holdings: Textual, Imagery, DTED, and vector data. The first three types are actually "pseudo" master holdings because they are stored as separate manuscripts, in their respective input formats, and maintained in separate data directories. Each holding manuscript is represented by a meta-feature within the Database Holdings Partition. Of these "pseudo" master holdings, only DTED may be converted to a Temporary Holding Partition (vector format) for further processing; however, due to its volume, it is prohibited from being added to the real master holdings (Tile Partitions). The fourth type, vector data, is maintained as a global, seamless (to the user) master holdings data base. In actuality, because of the large data volumes and limited on-line storage, the master holdings are segmented into non-overlapping Tile Partitions.

Tile Partitions are used to store the data over spatially distinct areas; however, master holdings data is not physically sectioned on tile boundaries. Data from master holdings that is wholly contained within a tile boundary will be placed within the appropriate Tile Partition. Master holdings data that crosses a tile boundary will be replicated in all the Tile Partitions it crosses; data preparatory operations ensure that these replicated features are recognized and handled properly to maintain data base integrity. In its initial distribution, the CATSS DBS master holdings is represented by eight tiles, each of which is 90 degrees in latitude by 90 degrees in longitude. Each tile is represented by a meta-feature in the Database Holdings Partition. Tile Partitions are accessed and maintained through the DBS ATB_viewer and customized software, but the contents of these partitions are never directly viewed or manipulated by the user.

Temporary Holdings Partitions: Temporary Holdings Partitions are accessed and maintained through both the DBS ATB_viewer and System 9; however, the contents of these holdings are displayed and edited only through the System 9 Data Capture and Edit utility (DCE) which is activated by the DBS ATB_viewer. A Temporary Holding Partition is actually an "orphan" System 9 project/partition because although it is a complete and valid partition data base, its project (Temporary Copy of the Global Project) is only temporarily created for data manipulations. Each Temporary Holding Partition is represented by a meta-feature in the Database Holdings Partition.

Data that is not an integral part of master holdings (the actual Tile Partition data) is considered to be a Temporary Holding; this includes data which is just being added to the system (via digitization, digital data conversion, or through the applications interface) or data which has been extracted from master holdings for perusal or manipulation.

All vector data content (features and attributes) of the DBS is defined in accordance with the "Defense Mapping Agency (DMA) Standard Supporting Mark 90, Section 100 Glossary of Feature/Attribute Definitions." This standard, DMA's Feature Attribute Coding Standard (FACS), defines a feature/attribute hierarchy ranging from a high-level feature category (feature grouping) to a specific feature code with associated descriptors or attributes. Within System 9 / DBS, the spatial representation of feature data is similar to the TTD/Mini-Topo structural definition. The System 9 / DBS data base structure supports a full topology, including the representation of both simple and complex features. While complex features are composed of one or more simple features, each simple feature has a spatial representation which defines the feature's composition and extent in terms of surfaces, lines, and nodes. Figure 4-2, "System 9 / DBS Structure Diagram," provides a conceptual view of these basic informational objects of the System 9 / DBS data base structure. Although this diagram does not represent the entire internal System 9 file structure, it does provide file and field information pertinent to understanding the vector feature representation under DBS.

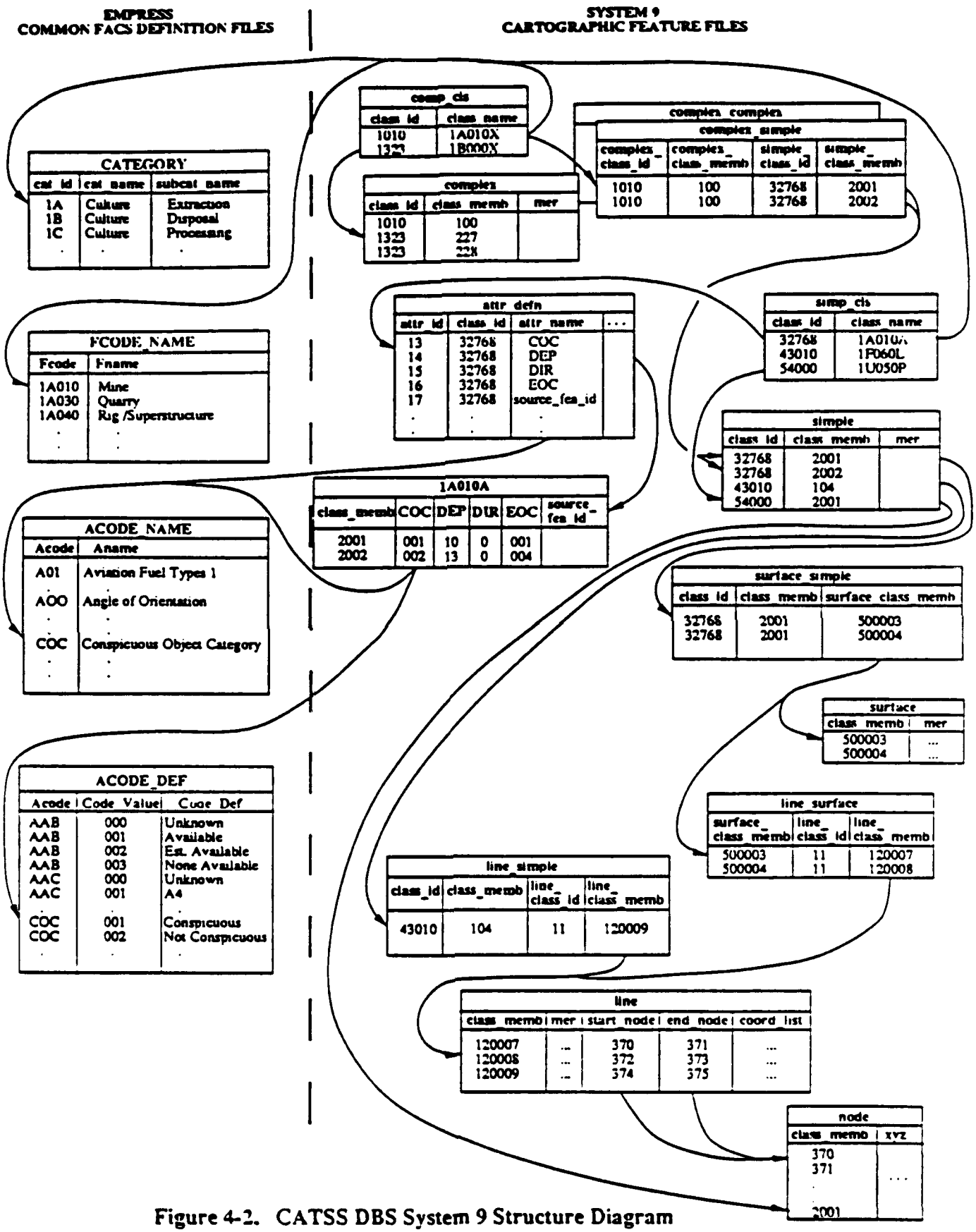


Figure 4-2. CATSS DBS System 9 Structure Diagram

4.4 SYSTEM FUNCTIONALITY

The following operational characteristics provide orientation of how the user, system functions, and data interplay within the CATSS DBS integrated system environment:

Types of DBS Users: The types of DBS users include the DBA/System Manager, Analyst, and external applications. The type of data, level of access/update, and available resource utilization are associated with the type of user and processing mode.

Modes of Operation: The laboratory DBS operates in one or more of the following general modes or system states:

- loading of external data sets or archived data
- interactive processing in support of ad hoc query or data preparation
- background processing of pre-defined 'batch mode' functions
- external access to data base resources

User Interface: The DBS interactive interface to users is graphically oriented in the form of a multi-window environment, whereby graphics are presented in concert with functional menus, entry of geographic parameters, and highlighting/annotating of processing results. External (Applications Software Interface) access to the DBS is limited to a menu-oriented non-graphic environment. All DBA/analyst interaction is controlled through the man–machine interface (MMI). The MMI encompasses the menu interface, hierarchically organized functional access, and display processing (where appropriate) required to communicate with the user, invoke functional processing, and report processing status and results.

Views of the Data: The interactive, background, and external applications typically interface with the data base on a sub-schema basis, whereby selected portions (i.e., AOI, data type, feature type, attribute set) of the overall data base are accessed during a user session. Meta-data exists which provides information about the data base contents and can be accessed in the form of directories, coverages, and data base and data set content summaries.

Concept of Master vs. Temporary Data: Holdings data exists at two levels within the DBS data base, as master holdings and as temporary holdings. Master holdings are those which have been fully entered into the DBS data base, and which cannot be modified, archived, or deleted except by the DBA. Temporary holdings are those which: are created through the data manipulation functions as part of creating data to be exported to the CATSS Applications Software; are in the process of being initially entered into the DBS as master holdings; or have been received from the CATSS Applications Software

and are in the process of being validated for entry into the DBS data base. Temporary holdings are also created as by-products and intermediate data as directed by users of data manipulation functions of the CATSS DBS, such as holdings data which is copied and/or filtered for experimentation purposes.

The operational characteristics described above are accomplished via the standard DBS interactive multi-window graphic interface and the supporting non-graphic single-window Applications Software Interface (ASI). The standard CATSS Data Base System (DBS) consists of a multi-window interactive graphic interface that provides the user with a variety of functionality to view and process data holdings of the DBS. The Application Software Interface (ASI) to the CATSS DBS is a menu-oriented non-graphical interface which was designed to perform many of the same data access and manipulation operations as the interactive DBS interface, but without the graphic window support. The design and functional interaction supported through the menu-oriented MMI was developed using c source code (to access System 9 menu handler utilities) and Unix shellscripts (for ATB_viewer commands).

The CATSS DBS MMI, including display characteristics, menu layouts, user communication, and process invocation, was tailored as much as possible to conform to the System 9 GIS MMI. Figure 4-3, "CATSS DBS Top-Level Menu Interface," illustrates the standard layout and content of the Sun console window for the standard CATSS DBS interface.

Throughout an interactive session, the CATSS DBS displays an overview graphics window (upper-left in the figure) representing current data base holdings. In addition, a menu window (right side of the figure) allows the user to interact with the CATSS DBS, via mouse or keyboard control, to peruse and/or modify data base holdings. Functionality of the DBS is organized according to the type of access/manipulation required. Briefly, the functionality available through the DBS interactive interface is described as follows:

Geographic Area Functions: During an interactive DBS session, the user is provided with a view of Master and Temporary Holdings on a worldwide basis via the Database Holdings Partition. A Geographic Area provides a viewport into these holdings at a larger scale. A Geographic Area is a logical entity named and defined by a minimum enclosing rectangle. This allows the user to view holdings within a Geographic Area (i.e., ad hoc area or pre-defined, user-named area such as United States, for example). Functionality is provided to allow the user to **Create** or **Delete** a Geographic Area. **Display** and **Remove Display** allows creation/removal of an additional graphic window containing holdings information limited to the area covered by a Geographic Area. **List** provides information about existing Geographic Areas.

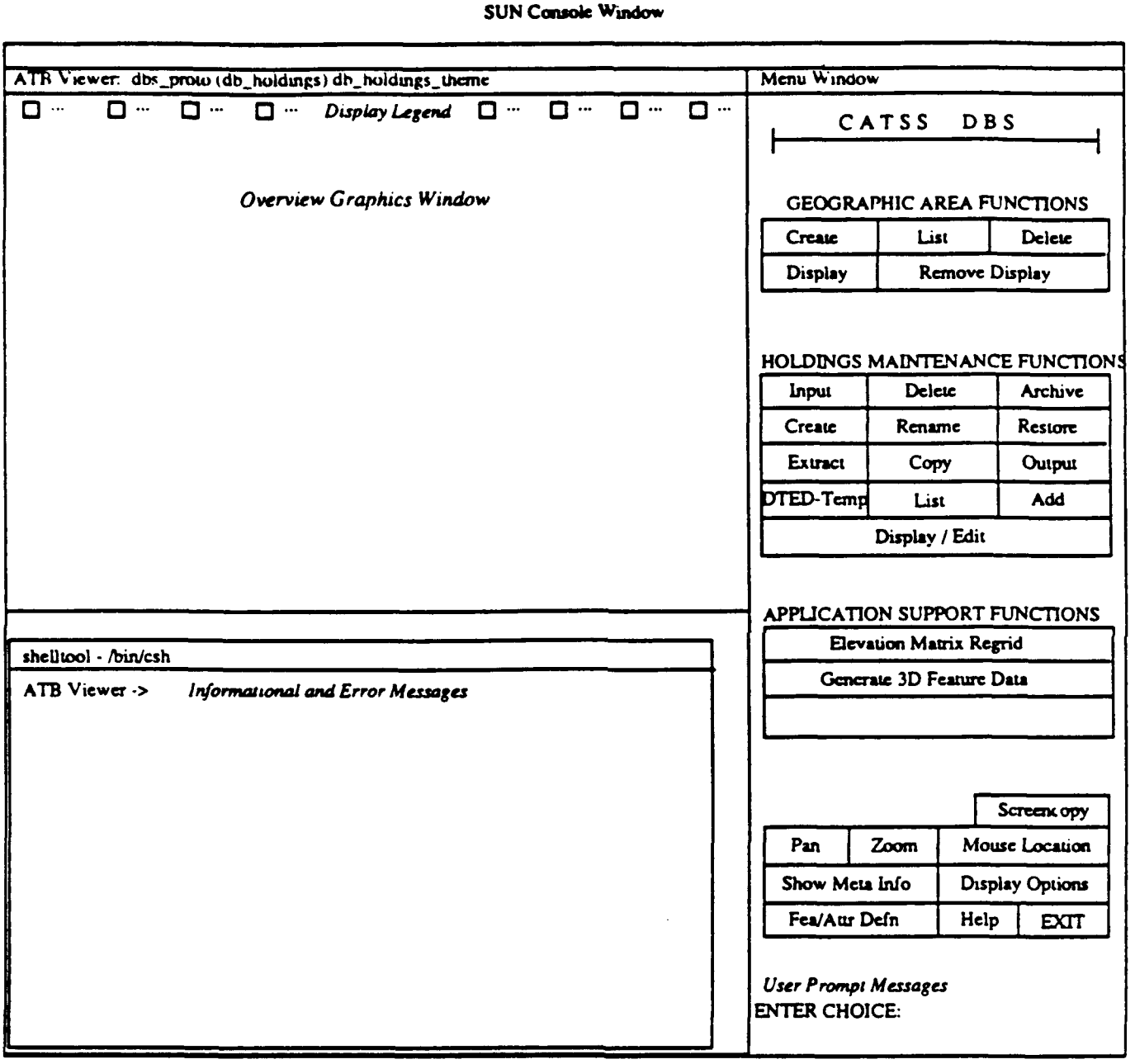


Figure 4-3. CATSS DBS Top-Level Menu Interface

Holdings Maintenance Functions: These functions are used to manipulate either Temporary or Master Holdings as specified below.

Input – allows input of a Temporary Holding from data in an external format/model which is acceptable as input to the DBS.

Delete – allows a Temporary Holding to be removed from the DBS.

Archive – allows a Temporary Holding (or Master Holdings for DBA) to be archived to secondary storage. Archival may take place to disk or magnetic tape, and original holding may remain on line.

Create – provides mechanism for creation of an empty Temporary Holding (useful for data which originates on DBS from hand-digitized data).

Rename – allows a Temporary Holding to be renamed.

Restore – allows restoration of a Temporary Holding (or Master Holdings for DBA) from an archived copy.

Extract – provides extraction of a new Temporary Holding from various combinations of other Master or Temporary Holdings, including specification of area of interest and feature content limitations.

Copy – allows a copy of a Temporary Holding to be made.

Output – provides mechanisms to reformat a Temporary Holding and converts it to an external model/format which is supported under the DBS.

DTED-Temp – a special support utility which provides conversion of DTED- formatted elevation matrix data to a vector model Temporary Holding so that it may be viewed and modified using standard System 9 functionality, including the Digital Terrain Model processing utility.

List – this function provides a list of all holdings of interest to the user. Information may be selected based upon area of interest, status of data, type of data, etc.

Add – a DBA-only function which provides addition of a Temporary Holding to Master Holdings.

Display/Edit – provides direct access to a Temporary Holding under System 9. Specifically, the user would most often elect to execute the System 9 Data Capture and Edit (DCE) utility which provides extensive functionality to display, query, and manipulate data within a Temporary Holding.

Applications Support Functions: No Applications Support Functions are currently implemented under the CATSS DBS. The menu provides a placeholder for functionality that might be desired for CATSS Applications at a later date. Suggested functionality includes:

Elevation Matrix Regrid – a function that would allow conversion of elevation data between a DTED Level 1 and Level 2 resolution.

Generate 3D Feature Data – a function that would allow creation of a three-dimensional (x,y,z) holding using a two-dimensional holding and an elevation matrix over the same area of interest.

Display Options: Various types of basic graphic display manipulation operations are provided through the generic Display Options. These include:

Screencopy – takes an image (screendump) snapshot of the contents of the Sun console window and saves it to a named file.

Pan – provides basic functionality to pan across (alter the center of) the current graphic display.

Zoom – provides basic functionality to rescale (viewing more or less data detail) the current graphic display.

Mouse Location – returns the geographic latitude/longitude coordinates for a user-specified mouse location within the graphic display.

Show Meta Info – used to obtain detailed information about specific meta-data viewed on the graphic display.

Display Options – provides various subfunctional display manipulations, such as data filtering, textual annotation, etc.

Fea/Attr Defn – provides access to, and query of, the CATSS DBS FACS-based schema definition.

Help – provides access to on-line help.

EXIT – used to terminate the CATSS DBS interactive interface.

MISSION

OF

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